The Evolutionary Transition from Anoxygenic to Oxygenic Photosynthesis and How it Changed the Earth

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The appearance of oxygen in the Earth's atmosphere about 2.2 billion years ago, a by-product of oxygenic photosynthesis invented by primitive cyanobacteria, stands as one of the major events in the history of life on Earth. It has long been supposed that anoxygenic photosynthesis existed prior to the advent of oxygenic photosynthesis and that modern groups of anoxygenic phototrophs are the descendants of these ancient bacteria. However, the evidence for this is indirect and primarily consists of arguments based on the lesser complexity of the photosynthetic apparatus of these organisms. Several lines of evidence suggest that horizontal gene transfer has been important in bacterial evolution in general and also in the evolution of photosynthesis. We have carried out structure-based sequence comparisons of reaction center complexes that have permitted us to construct a unified evolutionary tree incorporating most of the groups of phototrophs. This tree very strongly suggests that the common ancestors of all extant photosynthetic prokaryotes were indeed anoxygenic photosynthetic bacteria and that the core reaction center architecture of these organisms was a protein homodimer.